Flood Emergency Response System Using Multiple Criteria Decision Analysis

by

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Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Technology (Hons)
(Information and Communication Technology)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Information and Communication Technology Programme
Universiti Teknologi PETRONAS
In partial fulfillment of the requirement for the
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Approved by

____

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
MAY 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NUR NADRAH BINTI ROSLAN

ABSTRACT

Recently, several states in Malaysia have been affected by flood disasters, causing hundred thousands of people to be evacuated from their homes and some of the victims killed on the floods. Therefore, **flood emergency response** at early stage is very important to keep flood risk and its impact at the very minimum level. However, it is not easy to come up with the best flood emergency response plan. The reason is because flood management problems related to the emergency response are inherently complex, time-bound, involving with conflicting priorities and in need of high decision stakes. So, application of Multi-Criteria Decision Analysis (MCDA) is being studied and is used in this project. It can help search and rescue teams to manage those complexity and decisions load by combining value judgments and technical information in a structured MCDA decision framework. This report will discuss the currently research done on the project called **Flood Emergency Response System**. With a promising results after a few test, it shows that this system is a proven tools that help search and rescue teams to locate and save the flood victims efficiently based on their prioritization of their condition. The objectives of the flood emergency response system is to provide a platform for the rescuers to locate and prioritize which flood victims that they should save first. This system can provide an auto-generated ranking of the current flood victims available in the system for the rescuer to view which place that they should go first in order to save the victims. A brief overview of the system is presented and future research directions of this project are further discussed in this report. In summary, by making the links among flood knowledge, assumptions and choices more explicit by using the application of MCDA, the system is able to increase decision-making effectiveness, efficiency and transparency, which consequently can help the search and rescue teams to saves more lives and reduces flood management costs during the occurrence of flood disaster.

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ABBREVIATIONS AND NOMENCLATURES

AHP	Analytic Hierarchy Process
GUI	Graphical User Interface
MCDA	Multiple Criteria Decision Analysis
SDLC	System Development Life Cycle
UTP	Universiti Teknologi PETRONAS
WSM	Weighted Sum Model

CHAPTER 1
INTRODUCTION

1.1. Project Definition

This project will cover a system that will be used by search and rescue teams locating and saving each flood victims one by one based on their prioritization of their condition. This system is used to rank, locate and view the ranking that is produced by using the MCDA method. This project is presented by a prototype before it is implemented in the actual environment.

1.2. Background of Study

Flooding is the most common environmental hazard worldwide. Statistics provided by Centre for Research on the Epidemiology of Disasters shows that in 2013, 9,819 of people killed by floods was the highest number in the decade if compared with fatalities from other disasters (Centre for, 2014). The figure shows that deaths from floods has the largest share of natural disaster fatalities which in 2013, representing 45.4% of global disaster mortality (Centre for, 2014). While in Malaysia, floods are regular natural disasters which happen nearly every year during the monsoon season. Floods that hit Malaysia from 15 December 2014 to 3 January 2015 have been described as the worst floods in decades. More than 200,000 people affected while 21 people killed on the floods (2014-15, n.d.). So, floods can have devastating consequences and can bring many effects on the economy, environment and people. Moreover, floods also has become an increasingly worrying issue for country as direct global losses from this disaster kept increasing. These losses include drowning, severe injuries, property and infrastructure damages. Although there are many advanced technologies for protective measures against flood disaster has been deployed, the number of losses especially number of victims still kept increasing. So, the statement proved that since a flood protection system guaranteeing absolute safety is an illusion, another method of dealing with flood disasters need to be carried out. A National

Academy of Science panel (1982) concludes that ‘it is short-sighted and foolish to regard even the most reliable system as fail-safe’ as any flood containment structure will eventually be overcome (Gopalakrishnan & Okada, 2013). In addition to questioning the overall effectiveness of the hard (structural) approach to flood management (‘keep floods away from people’), European governments have taken the lead in promoting soft (nonstructural) flood risk management strategies (‘keep people away from floods’). One of the typical non-structural approaches in flood management include using Multiple-criteria decision analysis (MCDA) for flood management.

Looking into more details about this technique, MCDA can be defined as a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments. This technique typically has been used in this area because decision making in flood disaster context is often made in the presence of multiple, conflicting, incommensurate criteria, stakeholders and certain complexities. **Decision making** for protective measures in flood area is very important to take into account. Besides that, as time goes by, the effort to reduce the flood hazard and effect increased from time to time, so in modern times like these, advances in decision theory, new technology and computational capabilities have provided opportunities for more development and application of MCDA in this flood disaster context. The aim primarily is to improve sustainable flood hazard mitigation and emergency flood response for decision making. An example of application of this MCDA technique in flood disasters context is when Levy (2005) applies Multi Criteria Decision Support System (MCDSS) to improve flood response and recovery in the Yangtze River Valley, where flooding in 1998 caused over $30 billion US in economic losses and killed more than 3,600 lives (Wei et al., 2004).

In particular, this paper will continue to emphasize using MCDA for flood emergency response system. So, in this project, flood emergency response system using MCDA based concept is proposed, where there are three main components in its architecture which comprises of a database consists of the victims' information, MCDA techniques with emphasis on the Weighted Sum Model (WSM) and the user-interface. This emergency response system is developed to help the rescuer to decide on which is the most vulnerable victims that they should save first one by one before the others in order to prevent any bad things to happen such as loss of lives. This decision making will be made based on the information of the victims and by using the application of MCDA of the system. The WSM stated earlier is applied in order to rank each of the victims involved. In the final section, results are summarized and conclusions are made.

1.3. Problem Statement

1. **Decision making in flood events is usually tied with a high degree of complexity**. This is because of the scarce resources to be allocated and the conflicting priorities involved during the event. Furthermore, this is also due to the large number of stakeholders which induces a large number of conflicting decisions that need to be made. Wrong decision making can lead to late emergency response in reaching the most vulnerable victims.

2. **Late rescue operations can claim lives and increase losses**. That is why early response is very important. There have been many time where late rescue operations during high flood water are struggling to reach thousands of people who have been trapped in some of the flooding areas. Intermittent communications services; shortage of food and water supply; rescue efforts hampered by power outages; and roads that have been washed away by the floods are some of the difficulties that usually have to be borne by the rescuers and the victims if rescue operations did not happen during the early stage of flood disaster.

1.4. Project Objective

1. **To apply MCDA model in flood emergency response decision making**. With the development of this system, it aims to assist the rescuers to identify the most vulnerable flood victims in a flood area. This will ensure a faster and accurate decision can be obtained during rescue operations. Efficient decision making and transparency also can be increased significantly.

2. **To evaluate performance of the flood emergency response using the application of MCDA**. The system is designed to maximize responsiveness of emergency responses to the victims at early stage of flood events. Early responses to flood disaster from victims enable the rescuers to save more lives, minimize injuries, diseases and losses. It also enables a team of rescuer to prepare enough of all the basic necessities such as food and drink for the victims throughout a rescue mission.

1.5. Project Scope

The target user of this software is the search and rescue teams which this group of users will have the most benefit from this system. This system will help them to increase the efficiency on saving people in terms of many aspects by deciding on the priority of which victims that they should save first before the others. They are able to reduce their time and energy during rescue operations being held while indirectly being able to reduce the impacts of flood. Besides that, this system will utilize the concept of MCDA models and techniques, with emphasis on the WSM. The field of MCDA approaches is well-suited for eliciting and showing the criteria of flood preferences of participants. The WSM is used in order to assist in the identification of flood alternatives and the selection of appropriate flood emergency responses. A set of variable and criteria are defined to which will be further elaborated in the methodology. Flood victims' data will be weighted. With the weighting system, the rank of priority of vulnerable participants will be compared to each other. Some of the inputs are taken into assumption for research's purposes. A prototype system called 'Flood Emergency Response System' with certain functionalities will be developed at the end of project development. All the data of the victims will be stored in a centralize database which is accessible by the authenticated users through the software.

1.6. Relevancy and Feasibility of the Project

The overall scope execution of this project takes two semesters which is equals to eight months for completion of this project. The time span of the two semesters is divided into two parts which are Final Year Project 1 and Final year Project II. During Final Year Project I, the author focuses more towards the research and writing report while during Final Year Project II, project design and implementation is carried out.

CHAPTER 2
LITERATURE REVIEW

2.1. Floods in Malaysia

Flooding is the most commonly occurring form of natural disaster in Malaysia because of the geographical characteristic of the country that brings an abundance of rains during the monsoon seasons and also due to convection rains during the hot but humid weather type of periods in this country. There are a total of 189 river systems in the country which 89 of them are situated in Peninsular Malaysia while 78 is in Sabah and 22 is in Sarawak with all flowing directly to the sea (Shafie, 2009). From all of the rivers listed, 85 are prone to frequent flooding. From late last December 2014 until early January 2015, incessant heavy rainfall has triggered widespread flooding in Kelantan, Terengganu, Pahang and Perak. This flood events are caused by both riverine and coastal flooding. At least 21 people died and 200,000 of the citizens were forced to evacuate their homes as flood waters swept through the low-lying area of all these states (Mail, 2015). Sabah and Sarawak were also affected by this flood causing untold suffering to thousands of people.

The floods also reported to be the most tragically event when thousands of Malaysians that are affected by the floods, both young and old were left stranded wet, cold, sick and hungry for several days before help arrived to them. One mother was forced to feed her 6 months old infant with formula milk mixed with rainwater (2014-15, n.d). Besides that, reports of flood during that time also continue to pour in on intermittent communications services, shortage of food and water supply, rescue efforts hampered by power outages and roads that have been washed away by the floods (Subramaniam, 2014). All of these problems happen because of late response and inadequacies in planning to flood. So, this study is carried out to focus on flood emergency response. This is very important to ensure quicker responses so that flood impacts can be reduced while the rescuers will also have the benefits of having enough time to prepare all the necessities required for the flood victims.

Figure 1: This aerial view shows houses and plantations submerged in floodwaters in Pengkalan Chepa, near Kota Baru, Kelantan on December 28, 2014. (Flood control, December 2015)

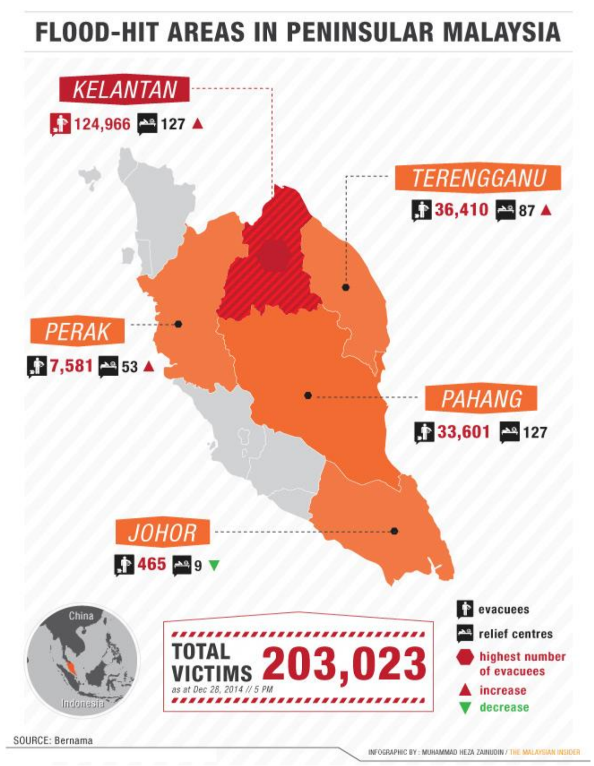


Figure 2: Statistics of 2014-2015 flood-hit areas in Peninsular Malaysia (Siew, 2015)

2.2. Flood Emergency Phases

There are four phases that have been studied for emergency management (The Four Phases, n.d.):

1. Mitigation

   It involves the evaluation of alternative mitigation measures for possible implementation in order to reduce flood chances of emergency happening or reduce damages effects of unavoidable emergencies in a region. Some of the typical mitigation measures include establishing building codes, zoning requirements and constructing barriers such as levees. An effective mitigation efforts are able to break the cycle of disaster damage, reconstruction and repeated damage from occurring.

2. Preparedness

   It involves the preparation of plans or procedures to save lives and minimize damage when an emergency occurs. It increase community's ability to respond towards disaster when it occurs. Preparedness measures can take many forms including the establishment of flood forecasting, monitoring and warning systems, evacuation procedures and public information services. Evacuation plans and stocking of food and water are both examples of things that can be done during preparedness phase.

3. **Response**

   A well-rehearsed emergency plan developed as part of the preparedness phase enables efficient coordination of resources allocation. Response actions carried out as soon as possible before, during and after hazard impact with the goals at saving lives, reducing economic loses and alleviating suffering. The response actions may include activities such as evacuation of threatened populations, activating search and rescue teams and the provision of basic necessities to flood victims.

4. Recovery

   During this phase, the goal of recovery is to return the community's system and activities back to their normal condition. Typical recovery actions include financial assistance to individuals, rebuilding of roads and bridges and etc. Recovery activities take place after an emergency.

2.3. Flood Emergency Response

As the country witnessed a considerable increment in the number, scopes and complexity of disasters and emergencies for the past few years, emergency response is very important to be taken care of. Gradual increases in water levels forcing the victims to evacuate their homes. When the flooding occurs, the victims need assistance to transfer them from the flood zone to a safe place. Emergency response's aim is to minimize the impacts of flooding on people by providing support and assistance. There are many activities that are carried out during flood emergency responses where emergency response itself can be defined as a series of appropriate actions and precautions in the event of a disaster. These include activities of identifying vulnerable people, evacuation and transport to safety areas, provision of accommodation and provision of emergency supplies. Before taking any actions, there are several factors that need to be considered in order to gather enough data related to the victims and their area surrounding. It is very important to get all the information related to the disaster such as the location of the flood area, quantity of food and drinks whether it is sufficient or not for the time being and presence of vulnerable members in the house. Therefore, an advanced and accurate decision making for flood emergency response system provided in a timely manner before and at the early stage of the flood event is very much needed. Decision making in flood emergency response can help to address the immediate and priority needs resulting from the disaster. It is important to recognize the most vulnerable victims based on their situations and mobilize the emergency personnel to the areas rather than initiate emergency operations to the least vulnerable areas first. Good plans and teams will result to faster and more efficient response to flood events and can ensure enough supplies are available for each of the victims affected. Thus, in this study, emergency response should focus on the decision and priorities of which groups of people that the rescuer should send their help first before the others.

2.4. Multiple Criteria Decision Analysis (MCDA)

In this current world, flood issues need to be dealt with in a more comprehensive manner. This integrated, holistic flood management vision can be realized through the application of Multiple Criteria Decision Analysis (MCDA). The notion of MCDA actually comes from the sixties in the last century. MCDA is a collection of methodologies and techniques to compare, select or rank multiple alternatives by incorporating conflicting criteria in a formal decision making process. It typically involves a high degree of uncertainties with certain complexities, high stakes, major resource implications and long-term consequences (Johnson, Scholes and Whittington, 2005). Despite a long history since the time it is being introduced, the development of MCDA approach is still under way. While there are new methods coming in constantly, MCDA methods also undergo constant improvements. Today, MCDA can be said as an established methodology with lots of books, thousands of applications, scientific journals and university courses introducing and using the approaches. MCDA applications are diverse covering various aspects in life ranging from environmental planning, water resources management, forestry, fisheries management, nuclear emergency management, climate policies until life-cycle analysis. The usefulness of this method is verified all the time in both theoretical analysis and practical applications in almost many aspects. The covering areas of this method made this flood related project also suitable to apply this MCDA approach. The system requires critical decision making to be made of, involve many stakeholders and public participation together with a large number of objectives such as minimizing loss of life, infrastructure damage and the emergency response time. Inside MCDA itself, there are a lot of methods which implement the MCDA approach. They differ both in implementation details and the scope of application. Among a wide variety of MCDA algorithms available to attain a final ranking or scoring of the decision options, some of the most common one are the Weighted Sum Model (WSM), Analytic Hierarchy Process (AHP), ELECTRE, PROMETHEE and Compromise Programming. In this project, WSM is selected being studied in more detail. Further explanation about the WSM will be elaborated in the next sub chapter.

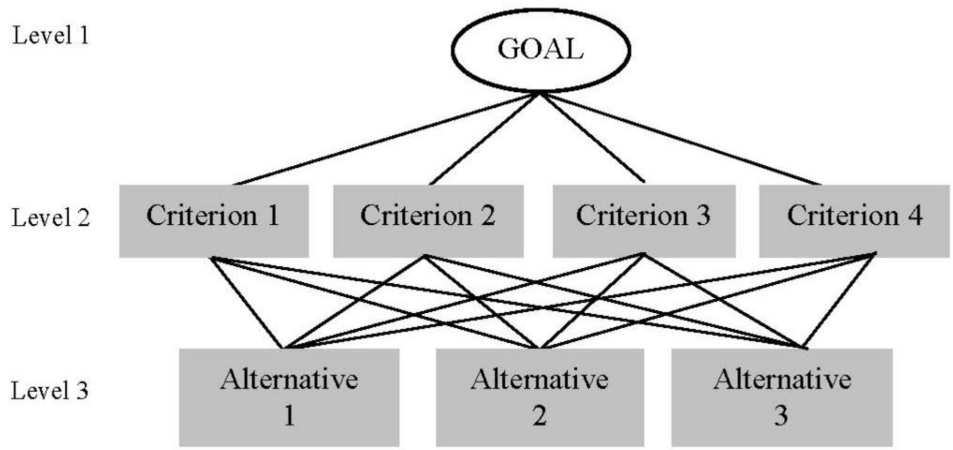


Figure 3: MCDA approach

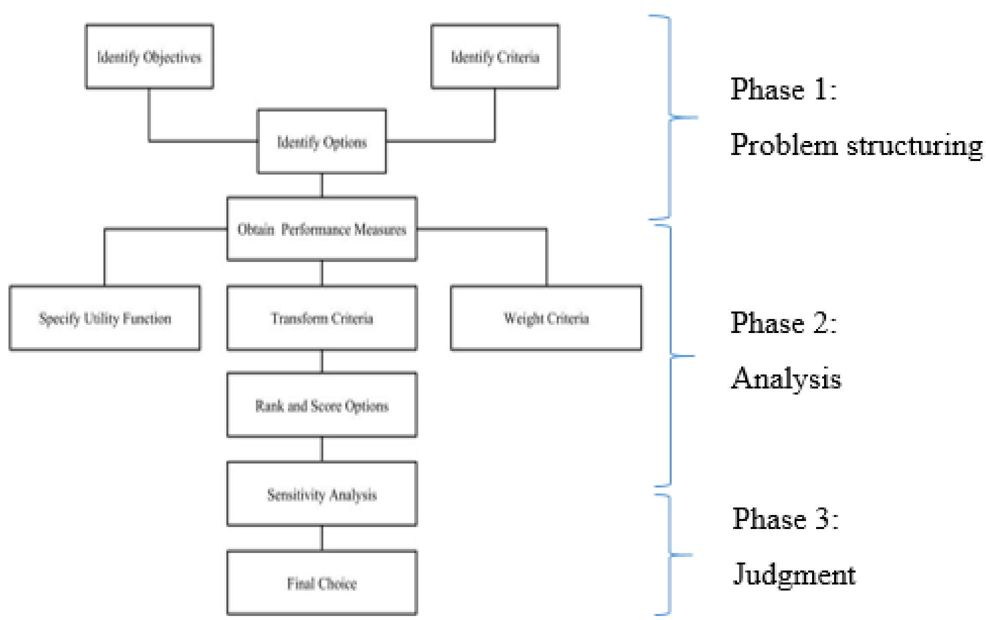


Figure 4: MCDA processes

General steps in an MCDA approaches include:

1. Problem structuring

   First, the objective of the analysis is defined. Next, all possible alternatives are identified and resulting to identification of all relevant criteria for evaluating those alternatives. Then, the next step is to come up with decision options and obtaining performance measures.

2. Analysis

   2.1. Criteria weighting

   This involves the process of obtaining information from decision makers about the relative importance of criteria. Weights may be expressed at either an ordinal or cardinal measurement level.

   2.2. Criteria transforming

   As the criteria are in different units they need to be transformed into commensurate units prior to aggregation in the ranking or scoring function.

   2.3. Option ranking and/or scoring

   The weights and transformed performance measures are combined to determine the overall performance of each option, relative to other options.

3. Sensitivity analysis and decision making

   Finally, a sensitivity analysis is performed to examine the robustness of the ranking outcome. Variation of MCDA methods, performance measures, and weights test the sensitivity of the result. The end result of the MCDA process is a recommendation consisting either of the best-ranked alternative or group of alternatives. The decision maker can then make a final choice.

2.5. Weighted Sum Model (WSM)

In decision theory, the weighted sum model (WSM) is the best known of MCDA method for evaluating a number of alternatives in terms of a number of decision criteria. In general, suppose that a given MCDA problem is defined on m alternatives and n decision criteria. Furthermore, let us assume that all the criteria are benefit criteria, that is, the higher the values are, the better it is. Next suppose that w_j denotes the relative weight of importance of the criterion C_j and a_{ij} is the performance value of alternative A_i when it is evaluated in terms of criterion C_j. Then, the total (i.e., when all the criteria are considered simultaneously) importance of alternative A_i, denoted as $A_i^{\text{WSM-score}}$, is defined as follows:

$$A_i^{\text{WSM-score}} = \sum_{j=1}^{n} w_j a_{ij}, \text{ for } i = 1, 2, 3, \ldots, m.$$

Figure 5: WSM formula

For a simple numerical example suppose that a decision problem of this type is defined on three alternatives A_1, A_2, A_3 each described in terms of four criteria C_1, C_2, C_3 and C_4. (For this study, alternative A = family while criteria C = criteria of flood e.g. number of family members. This algorithm applied for the system will be elaborated further in the next chapter). Furthermore, let the numerical data for this problem be as in the following decision matrix:

	C_1	C_2	C_3	C_4
Alternatives	0.20	0.15	0.40	0.25
A_1	25	20	15	30
A_2	10	30	20	30
A_3	30	10	30	10

Table 1: Decision matrix

For instance, the relative weight of the first criterion is equal to 0.20, the relative weight for the second criterion is 0.15 and so on. Similarly, the value of the first alternative (i.e., A1) in terms of the first criterion is equal to 25, the value of the same alternative in terms of the second criterion is equal to 20 and so on. When the previous formula is applied on these numerical data the WSM scores for the three alternatives are:

$$A_1^{\text{WSM-score}} = 25 \times 0.20 + 20 \times 0.15 + 15 \times 0.40 + 30 \times 0.25 = 21.50.$$

Similarly, one gets:

$$A_2^{\text{WSM-score}} = 22.00, \text{ and } A_3^{\text{WSM-score}} = 22.00.$$

Thus, the best alternative (in the maximization case) is alternative A2 (because it has the maximum WSM score which is equal to 22.00). Furthermore, these numerical results imply the following ranking of these three alternatives: A2 = A3 > A1 (where the symbol ">" stands for "better than").

CHAPTER 3
METHODOLOGY

3.1. Introduction

In this chapter, the methodology being used is going to be discussed and further elaborated. The time to develop this system is 7 months. There are two main compartments of the methodologies that are used in this study which are the research methodology and the development methodology. For the development methodology, software development life cycle (SDLC) of agile methodology has been chosen. Besides that, a qualitative research methodology also has been carried out for research and deeper analysis. Broader elaboration of the result will be discussed further in the following sections of the report.

3.2. Research Methodology

The research methodology requires gathering relevant data from the specified papers and information from web search for the purpose of development of the system. These are the methods and platform used to collect data and information about the project:

1. Academic research publishing
   Though Google Scholar (http://scholar.google.com) and UTPedia (http://utpedia.utp.edu.my), the author is able to grab few researches and literatures on similar topic with the project proposed. The author is able to gain more insight in current tools and technology and also their implementation in today's world by reading through the literature reviews.

2. Technology, technical blogs and Internet
   There are a lot of educational and technical website and blogs available on the Internet, which provides and delivers all the information needed for the author during the development of the system.

3. Advice from experts

   Author seeks experts review and advice from theoretical and conceptual advice from supervisor regarding the all the contents related to the project.

Figure 6 below shows the steps taken during research phases. Project planning involves selecting topic, brainstorming and getting a project approval. Literature review step is done by conducting and analyzing past studies/research papers. Data gathering and analysis is done primarily to obtain the score for WSM algorithm. Tools required and project feasibility is determined before developing the system architecture. Quick design is a final step to come out with mock or illustration of the project Graphical User Interface (GUI).

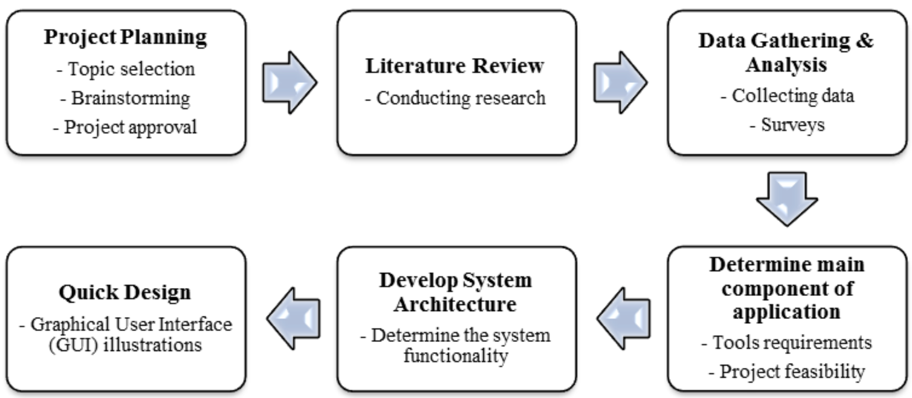


Figure 6: Research methodology

3.3. Development Methodology

The project is developed by using agile methodology. The main reason of using this approaches is because its nature which enhances the evolutionary of development and delivery. Agile model is a type of incremental model. The iterative nature of agile development allows features to be delivered incrementally, enabling some benefits to be released early as the product continues to develop. However, for every releases of the product, each will be thoroughly tested to ensure the software quality is maintained. Testing is integrated throughout the life cycle of agile methodology, enabling regular inspection of the working product as it develops. This allows the author to make adjustments if necessary and gives the author some early sight of any quality issues came up from the product. More freedom of time and options are obtained than if the software was developed in a more rigid sequential way like the traditional waterfall methodology. The clear visibility in agile development helps to ensure that any necessary decisions can be taken at the very earliest possible time.

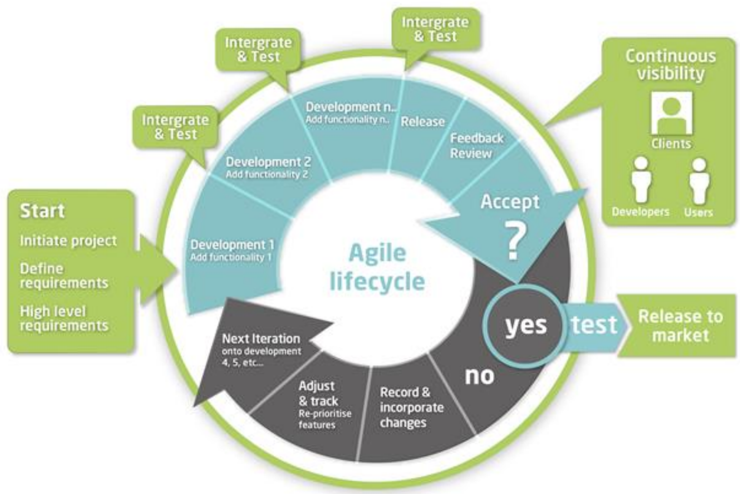


Figure 7: Agile methodology

3.3.1. Project Phases

1. Project Initiation

   Project initiation is the first phase in the methodology. In project initiation, the requirements of the projects are discussed and documented. During this phase, the target user and the scope for this system were defined and analyzed. The analysis of the project is done in the project initiation phase to find out the requirements for developing this system. Some other activities to collect the data for project initiation is by:

   i. Gathering feedback from targeted users on criteria that is important to the victims during flood evacuation and emergency response.
   ii. Design on how the application should look like.
   iii. Draw a rough flow architecture of the system.

Result of users' feedback will be further elaborated in the next sub topic of data gathering analysis.

2. Project Planning

   Project planning is the second phase for the project described in the methodology. In this phase, the estimated time, the software used and the software language were defined. HTML, PHP and MySQL are the main things that are being used throughout software development of the system. Besides that, during this phase, the author also plan on how to execute and run the application.

3. Project Design

   The third phase of the project is to come out with a proper design for system. Designing and coding the application is done during this phase. Some other activities that is done during project design is to:

   i. Divide the entire program into separate, individual, smaller modules.
   ii. Code the program module-by-module, debugging and improving the codes as the development goes on.
   iii. Combine all the individual modules into a single program.
   iv. Specify all the specifications.

   Figure 7 below will show the proposed designated architecture of the system. Besides, this system is also designed with the data will be stored in a centralized database which is accessible by the certain authenticated users.

4. Project Development

   The fourth phase of the project is to start developing the system.

   This phase can be conclude as testing and implementation stage of the system.

   i. Testing the application.
   ii. Checking and comparing prototype with other available similar projects.
   iii. Asking a few users (randomly selected) to test the application to get their feedback regarding the usefulness of the system.

3.3.2. System Architecture

Figure 8 shows the design of the system architecture for flood emergency response system. From the figure, the flood victims will actually send their information through SMS. Then, their information is stored in the database to be used by the system. Meanwhile, rescuer and adminstartor start their operation with the system by logging in and accessing the system. WSM algorithm is used by the system to calculate and give ranking of flood victims involved based on their prioritization. The software will be developed using PHP, MySQL and HTML language.

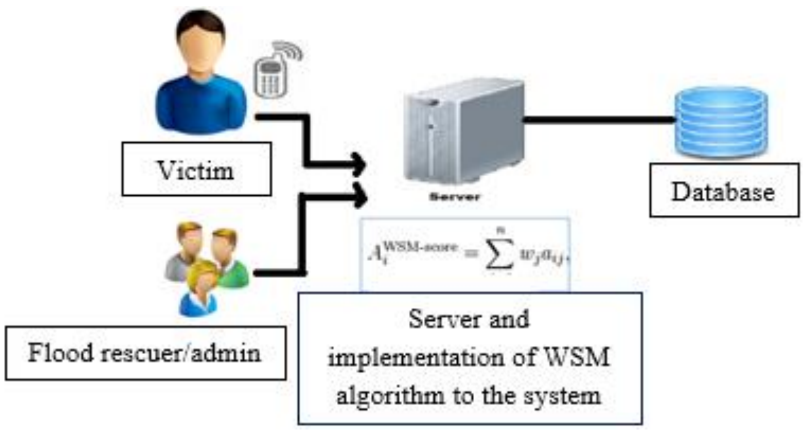


Figure 8: Proposed architecture

3.4. Tools Required

To develop this project, there are several tools and requirements needs to be filling to run the system. The project revolves around database and the way that it can be manipulated, therefore it is required that there is a software to cater for the prototype during the development process of the system.

Below is the minimum requirement and tools required:

Hardware
Personal computers with Windows operating system
Software
Xampp 1. PHP 5.3.10 2. MySQL 5.5.20 3. phpMyAdmin 3.4.10.1

Table 2: Tools required

3.5. Gantt Chart

FYPI		**Week**													
No.	**Activities**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	Requirement planning phase														
2	Identification of problem														
3	Define objective of the project														
4	Define scope														
5	Preliminary research														
6	Literature Review														
7	Selection of tools														
8	Interim report submission														
9	Proposal defense														

Table 3: Gantt chart for FYPI

Key Milestones:

1. Submission of project proposal (Week 3)
2. Submission of interim report (Week 12)
3. Proposal defense (Week 13)

FYPII		Week													
No.	**Activities**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	Project Development														
1.1	System design														
1.2	Coding														
1.3	Testing														
2	Pre-SEDEX														
2.1	Prepare poster														
2.2	Prepare presentation														
3	Technical paper submission														
3.1	Prepare technical paper														
4	Dissertation submission														
4.1	Prepare dissertation														
4.2	Review dissertation														
6	VIVA presentation														
Process															
Milestone															

Table 4: Gantt chart for FYPII

3.6. Data gathering analysis

In this topic, the results of the questionnaires that had been carried out were recorded and tabulated in the form of pie charts so that it would be easier to refer and retrieve the data. The contents of this chapter will serve as a qualitative and quantitative overview of the data collected. The survey is developed by using Google Form and has been distributed to the people through online. There are 40 respondents participated in this survey. Online survey is chosen due to the ease of use and larger number of respondent can be reached with just a single click within a short time of period. Objective of this survey is conducted is to get the score for WSM algorithm that will be used later in this system.

Pie charts below show the data tabulated from the conducted survey:

Question 1: Gender (Male / Female)

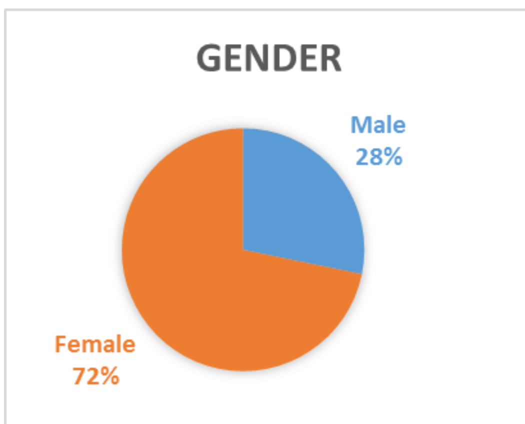


Chart 1: Survey question 1

Based on the pie chart above, the respondents of the survey are mainly female dominating with 72% while male only with 28%. The first question is conducted in order to know more about the gender of those whom completed the survey.

Question 2: Age (<18 / 18-25 / >25)

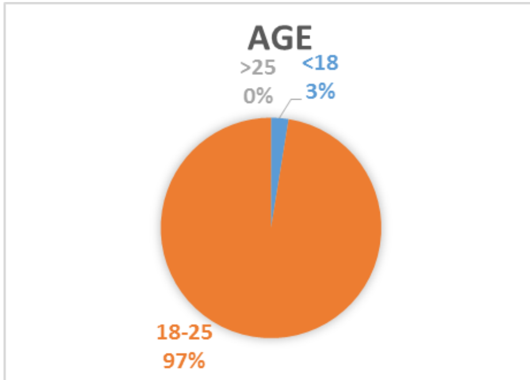


Chart 2: Survey question 2

From the pie chart above, it can be seen that most of the respondents came from the 18-25 age group which is 97% of them followed by less than 18 years old's age group which is 3%. However, none of the respondents are at the age of 25 years old and above. The second question is carried out to know about the age group of the respondents.

Question 3: Occupation (Student / Worker / Other)

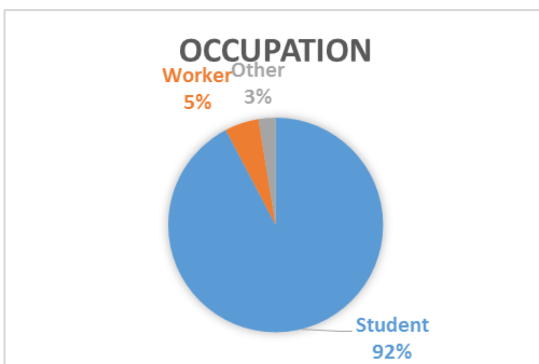


Chart 3: Survey question 3

The respondents of the survey comprises of UTP students, high school students, working adults and other occupations. 92% of the respondents is students while the rest of them are 5% worker and 3% with other occupations. The author believed that by having various respondents, it would be a great help in finding feedback regarding the system.

Next questions are carried out to know about which is the most to the least important criteria during flood emergency response. As we all know, there are a lot of criteria during flood event. However, for this project purposes, only some of the criteria below are taken into assumption for the development of this system. For the next questions, the respondents are given a set of options on where they are able to choose the scale of each criteria given.

Question: From your point of view, please rank the following criteria based on their priorities during flood evacuation process. The scale's range is illustrated as shown in the table below:

Scale value	**Interpretation**
1	Less important
2	Slightly important
3	Moderate important
4	Very strong important
5	Extreme important

Table 5: Scale

Question 4: Insufficient food/drinks

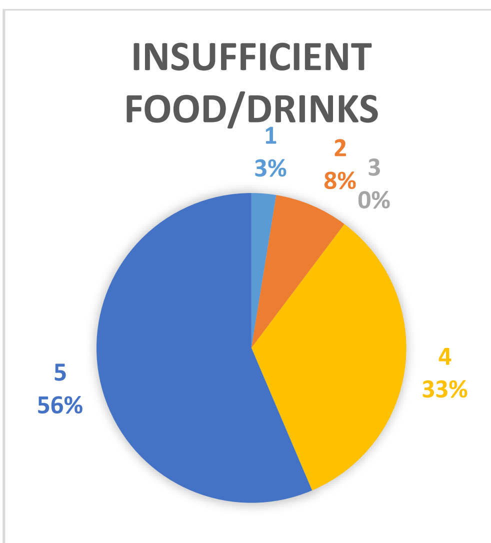


Chart 4: Survey question 4

Question 5: Number of family members

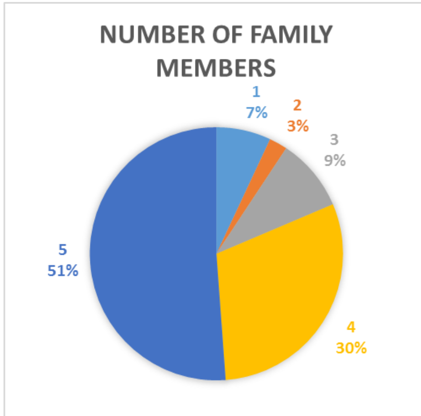


Chart 5: Survey question 5

Question 6: Number of children/elderly people

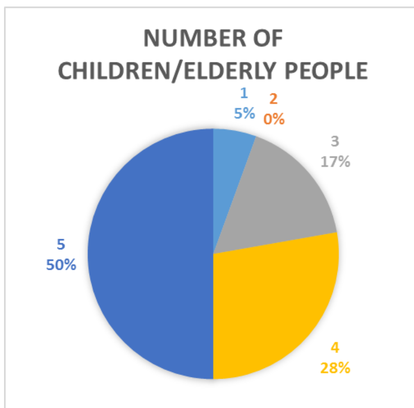


Chart 6: Survey question 6

Question 7: Level of flood water

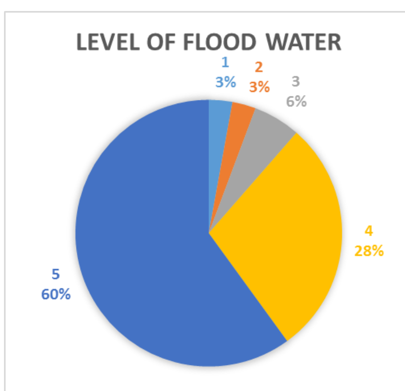


Chart 7: Survey question 7

Question 8: Location of the victims from the flood rescuer place

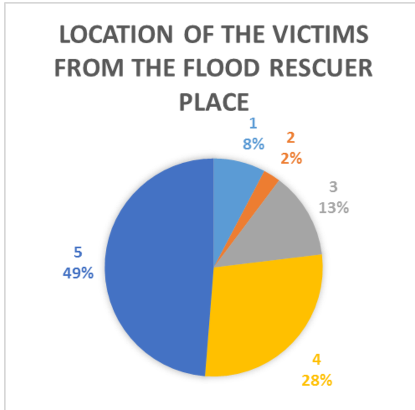


Chart 8: Survey question 8

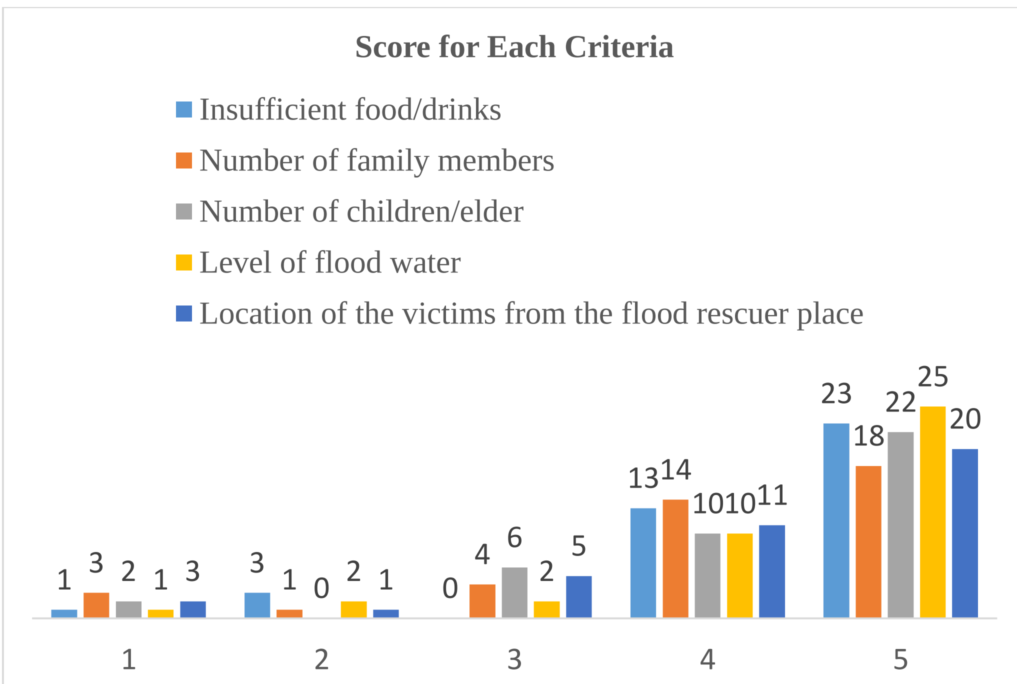


Chart 9: Summary of survey question 4 to 8

The bar chart above shows the result of the user feedback which is to be implemented in the WSM algorithm. The chart shows that most of the users choose all the criteria to be extreme important. However, the two most important criteria that can be seen to be the most important among the others are level of flood water and insufficient food or drinks.

Score / Criteria (C)	**1**	**2**	**3**	**4**	**5**	**Average Weighted Score**
Insufficient food/drinks (C_1)	1	3	0	13	23	0.205
Number of family members (C_2)	3	1	4	14	18	0.192
Number of children/elderly people (C_3)	2	0	6	10	22	0.201
Level of flood water (C_4)	1	2	2	10	25	0.208
Location of the victims (C_5)	3	1	5	11	20	0.194
Total						1.0

Table 6: Average weighted score

Total Weighted Score for Each Criteria:

Insufficient food/drinks

1(1) + 3(2) + 0(3) + 13(4) + 23(5) = 174

Number of family members

3(1) + 1(2) + 4(3) + 14(4) + 18(5) = 163

Number of children/elderly people

2(1) + 0(2) + 6(3) + 10(4) + 22(5) = 170

Level of flood water

1(1) + 2(2) + 2(3) + 4(10) + 25(5) = 176

Location of the victims from the flood rescuer place

3(1) + 1(2) + 5(3) + 11(4) + 20(5) = 164

Total weighted score for all criteria

174 + 163 + 170 + 176 + 164 = 847

Average weighted score:

Insufficient food/drinks

174 / 847 = 0.205

Number of family members

163 / 847 = 0.192

Number of children/elderly people

170 / 847 = 0.201

Level of flood water

176/847 = 0.208

Location of the victims from the flood rescuer

164 / 847 = 0.194

Total average weighted score

0.205 + 0.192 + 0.201 + 0.208 + 0.914 = 1

Therefore, based on the figures above, it shows that the level of flood water is the most important criteria to take into account when deciding of saving victims from flood disaster. The second criteria that get the next priority is insufficient of food/drinks. This is followed by number of children/elderly people and the location of the victims from the flood rescuer place. Last criteria in this study that is take into account is the number of family members in a flooding house.

Criteria	Ranking
Level of flood water	1
Insufficient food/drinks	2
Number of children/ elderly	3
Location of the victims from the flood rescuer place	4
Number of family members	5

Table 7: Ranking of criteria

Note that the above ranking above is taken into assumption for the project purposes for the time being.

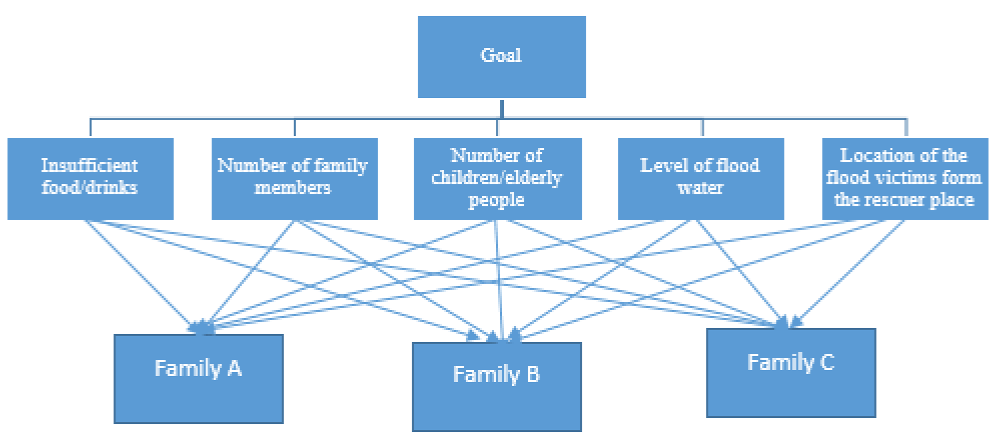


Figure 9: Example of MCDA approach using criteria and alternatives

Figure above shows an example of how the score will then be used to rank each victims by using MCDA approaches.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. System Site Map

There are two types of user that will be using this system which are the system administrator and the rescuers. Each user have different access level. For instance, administrator will have the overall control of the system while rescuers will have restricted access to the system on where they will not be able to access to the database of the system. Below is the conceptual web site diagram of the system. Below is the conceptual web diagram of the system.

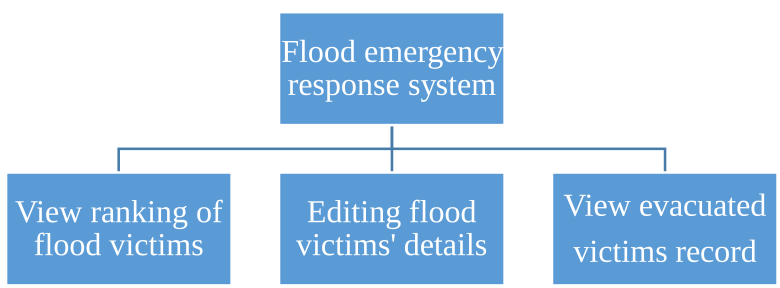


Figure 10: Conceptual web design

Figure 4 below shows the activity diagrams of flood emergency response system whereby there are three main modules to be developed.

1. **Module 1: View ranking of flood victims**

   This module should allow search and rescue teams and administrators to view victims’ details which is previously stored in the database.

2. **Module 2: Editing flood victims’ details**

   Other than viewing victims’ details, the system should also allow the administrator and the flood rescuers to edit the records which include modifying and deleting details (transferring the details of the respected victims into another database designed for the victims that have been saved/evacuated).

3. **Module 3: View evacuated victims records**
   This module should allow flood rescuers and administrators to view records of the victims that have been evacuated to safe places.

4.2. Activity Diagram

Based on all requirements gathered in the requirement analysis phase, a high level design of the system is developed. An activity diagram is constructed by identifying the main functions of the system described during the requirement analysis.

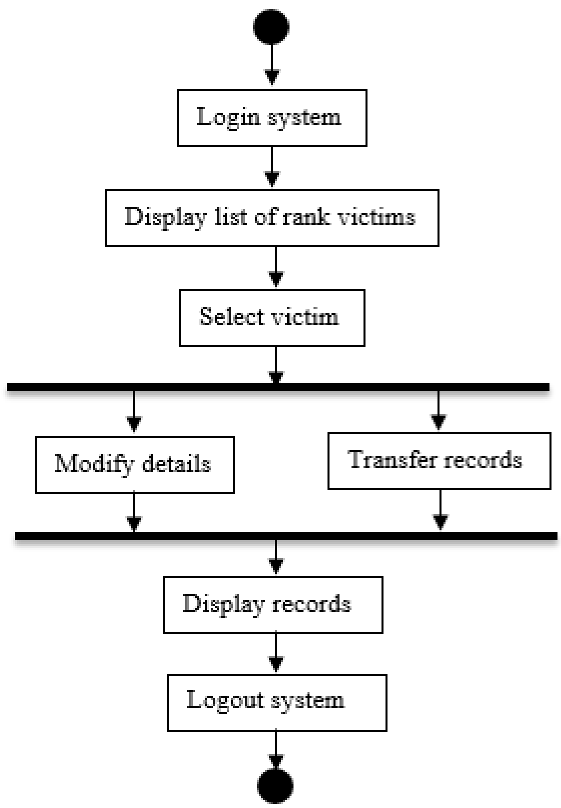
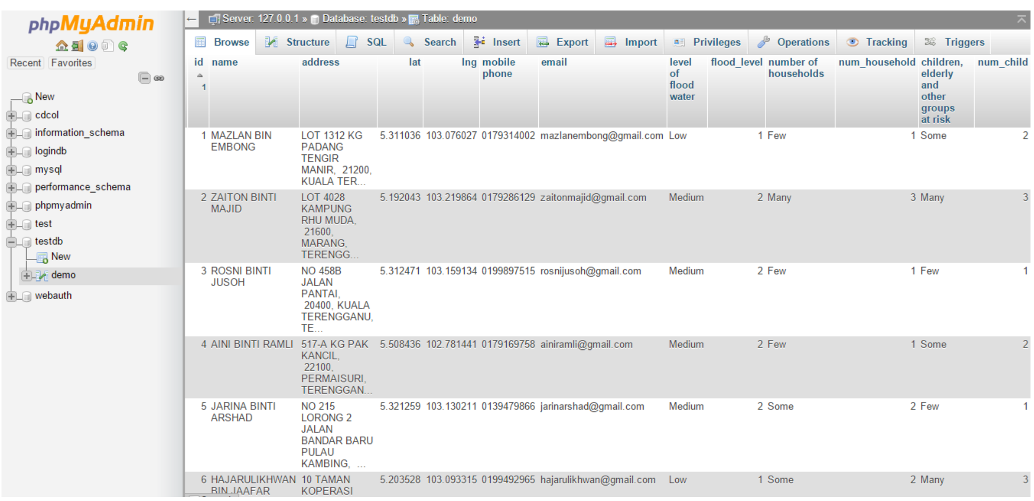


Figure 11: Activity diagram

4.3. Database

Field	Description
id	Unique id for victims
name	Name of the victims
address	Address of the victims
lat	Latitude
lng	Longitude
mobile phone	Mobile phone number
email	Email address
flood_level	Level of flood water
num_household	Number of households
num_child	Number of children, elder or other people at risk
distance	Distance from the victims and rescuers
food_level	Insufficient food/water

Table 8: Centralized database containing details of the victims



id	name	address	lat	lng	mobile phone	email	level of flood water	flood_level	number of households	num_household	children, elderly and other groups at risk	num_child
1	MAZLAN BIN EMBONG	LOT 1312 KG PADANG TENGIR MANIR, 21200, KUALA TER...	5.311036	103.076027	0179314002	mazlanembong@gmail.com	Low	1	Few	1	Some	2
2	ZAITON BINTI MAJID	LOT 4028 KAMPUNG RHU MUDA, 21600, MARANG, TERENGG...	5.192043	103.219864	0179286129	zaitonmajid@gmail.com	Medium	2	Many	3	Many	3
3	ROSNI BINTI JUSOH	NO 458B JALAN PANTAI, 20400, KUALA TERENGGANU, TE...	5.312471	103.159134	0199897515	rosnijusoh@gmail.com	Medium	2	Few	1	Few	1
4	AINI BINTI RAMLI	517-A KG PAK KANCIL, 22100, PERMAISURI, TERENGGAN...	5.508436	102.781441	0179169758	ainiramli@gmail.com	Medium	2	Few	1	Some	2
5	JARINA BINTI ARSHAD	NO 215 LORONG 2 JALAN BANDAR BARU PULAU KAMBING, ...	5.321259	103.130211	0139479866	jarinarshad@gmail.com	Medium	2	Some	2	Few	1
6	HAJARULIKHWAN BIN JAAFAR	10 TAMAN KOPERASI	5.203528	103.093315	0199492965	hajarulikhwan@gmail.com	Low	1	Some	2	Many	3

Figure 12: Database using phpMyAdmin

In this project there is one centralized database is used. The database consist of one table as shown above which contains the victims' details and where the id is the primary key.

4.4. System Design

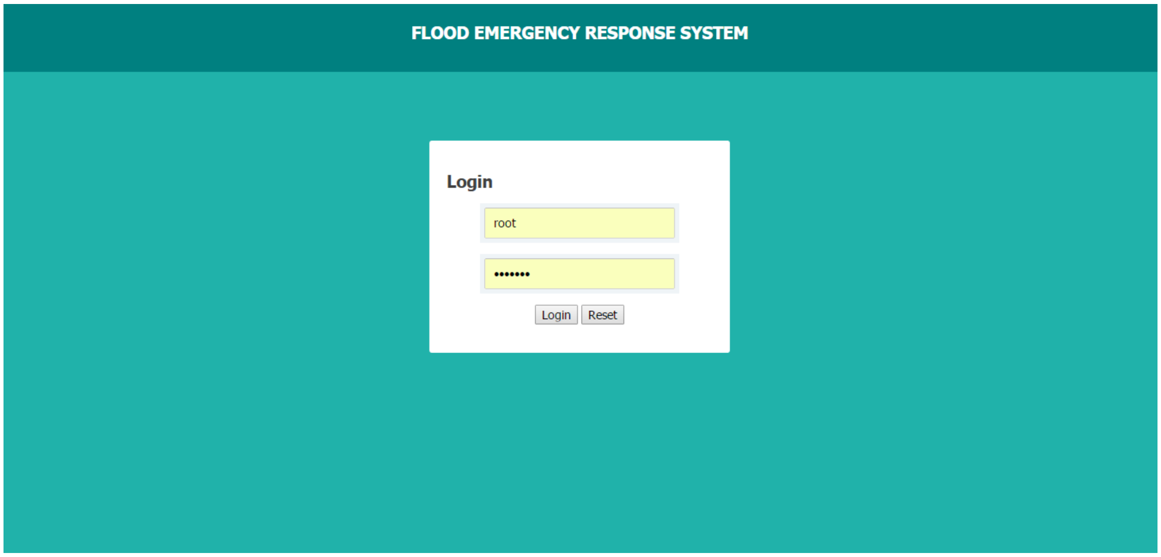
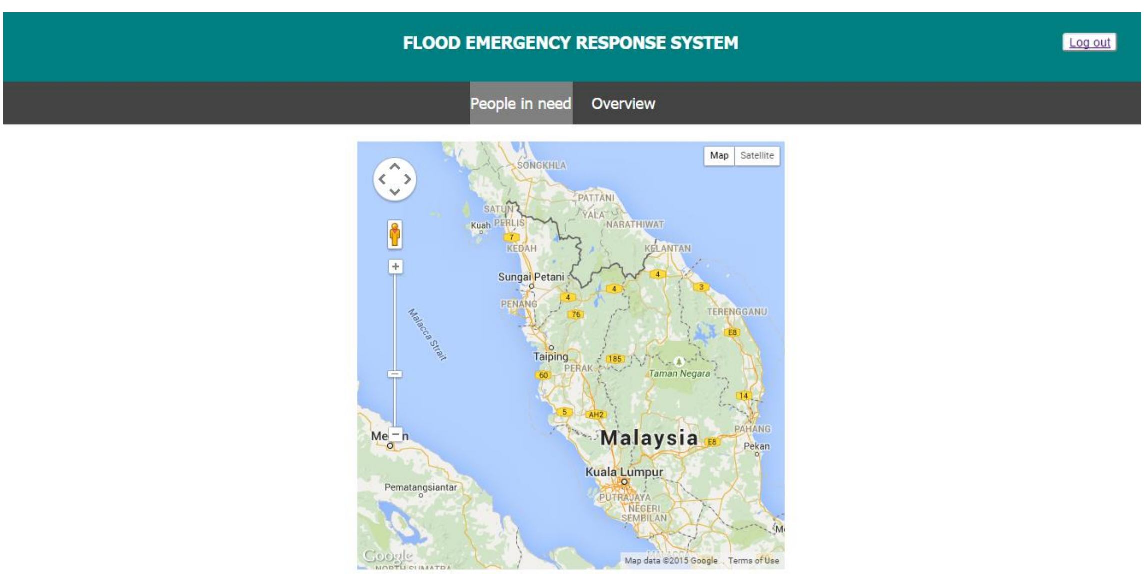


Figure 13: Login page

Figure 12 above shows the interface of the login page. The user needs to enter correct username and password. Only authorized users may log in into the system. Once login success, the user will directly go to homepage of the system otherwise if login is not successful, an error box will be prompted out showing that the user has entered invalid username or password.



No	ID	Name
1	8	ZULKIFLI BIN SALLEH
2	2	ZAITON BINTI MAJID
3	11	NORHAYANI BINTI ABU BAKAR
4	10	NORAHAIDA BINTI MOHD NAWI
5	4	AINI BINTI RAMLI
6	7	MOHD YASIN BIN ISMAIL
7	9	ANITA BINTI AB GHANI
8	6	HAJARULIKHWAN BIN JAAFAR
9	5	JARINA BINTI ARSHAD
10	3	ROSNI BINTI JUSOH
11	1	MAZLAN BIN EMBONG

Total number of families: 11

Figure 14: Homepage

In the home page, user will be able to view a map showing the location of each victims involved and also the ranking of the victims that has been tabulated in the form of table. The list of victims is being ranked from the most vulnerable situated at the top of the list while the least vulnerable will be placed at the bottom of the list. This rank module is developed for the purpose to help search and rescue teams to save the victims most in need first in order to avoid any bad things from happening to them. Besides that, for each row in the id and name columns, user will be able to click on it and the user will be linked to another page. On that page, the user is able to see the details of the selected victims. The page is shown in figure 14.

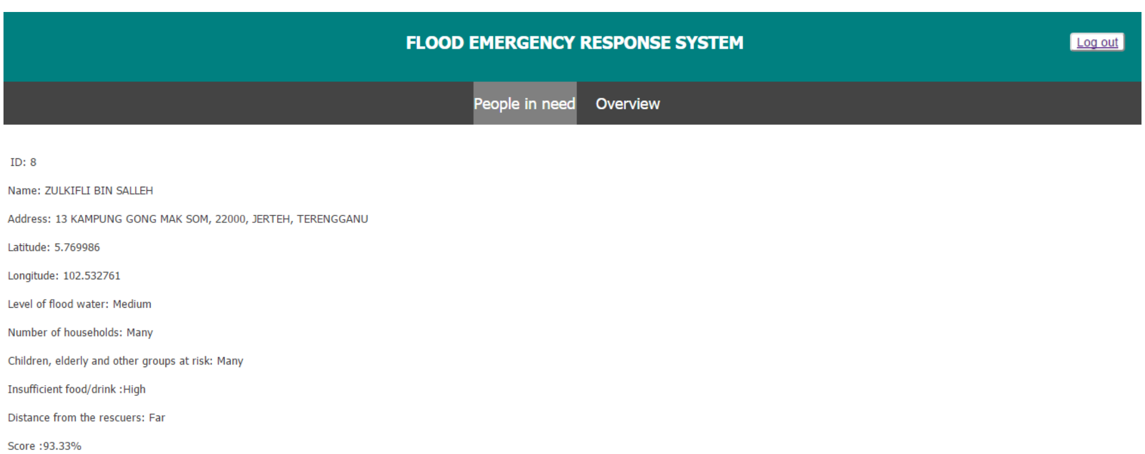


Figure 15: Details of the victim

4.5. Result of Testing

The project needs to be tested for conformance with the system requirements stated in the early stage. The developer needs to test the system that deals with database where the information of the user is stored and synchronized. Log in function need to be functioning correctly in line with the username and password. Plus, the algorithm implemented in the system should be working successfully in order to come up with the proper and correct ranking. For each rank of the victims should provide some information i.e. score of the rank. All the details obtained by the user and the system will be recorded and updated where the admin and the flood rescuers can view it when he/she log into the system. Besides, testing also involves syntax, functionality and logical errors. No major problem found in this testing.

4.6. Discussion

The requirement analysis have been done by gathering all the required information through questionnaires, observation and walkthrough on the existing system. There are several challenges that is need to be overcome in order to achieve the objectives of this project.

However, successful analysis of the study on the system mechanism which can be used to help the search and rescue teams to save people has been achieved. The successful design and development of the system that can generate the ranking of the flood victims based on their current situation has been achieved. The execution of the system using all necessary data shows that we managed to achieve correct result while taking the advantage of the implementation of MCDA algorithm in the system.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

Flood management problems are inherently large scale and consists of high complexities which it usually involving thousands of variables, competing alternatives and value-laden judgments. The importance of flood risk management is likely to increase because of climatic change and the growth of populations in coastal areas. The proposed MCDA framework for flood management assists in visualizing, analyzing, and integrating technical and social emergency management information such as flood damage estimation functions and evacuation route simulations. The WSM method was used for modeling the preferences of the stakeholders during flood, for weighting criteria, for aggregating data obtained and for prioritizing the final options. There several recommendations that need to be accounted for as it will help the improvement of the project throughout the development process. The development of Flood Emergency Response System could be enhanced in the future in order to add its capability to be preferred saving aid tool for search and rescue teams. The recommended future for this flood emergency response system is to link the system with SMS for the victims to provide their information. Besides, another improvement that can be done is by involving more criteria to be taken into consideration into this system. This is because this project only covers the scope of only some selected criteria. In the future, it is possible to continue enhancing the system by adding in more criteria so that more precise decision of prioritizing victims based on their vulnerable situations can be achieved. More research on user information needed and system's content to help during flood evacuation should be done. This will definitely enhance the system to be more efficient and complex in terms of assisting search and rescue teams to save the victims. A comprehensive and efficient system will bring many advantage which then consequently can help to protect more lives, property, infrastructure, and the environment. In short, MCDA for flood emergency response was shown to increase decision making efficiency and transparency. For the conclusion, the system is able to help search and rescue teams in their operation to save flood victims in a more efficient way.

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APPENDICES

Flood Emergency Response System

This system is designed to decide on the priorities of which families/victims that the search and rescue team should save first during the early stage of flood events based on their level of risk and vulnerability.

Gender

- Male
- Female

Age

- <18
- 18-25
- >25

Occupation

- Student
- Worker
- Other

From you point of view, please rank the following criteria based on their priorities during flood evacuation process. (The scale is ranging from scale 1 : the least important to scale 5 : the most important)

	1	2	3	4	5
Insufficient food/drinks					
Number of family members					
Number of children/elderly people					
Level of flood water					
Location of the victims from the flood rescuer place					

Submit

100%: You made it.

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APPENDIX I: Survey questionnaires